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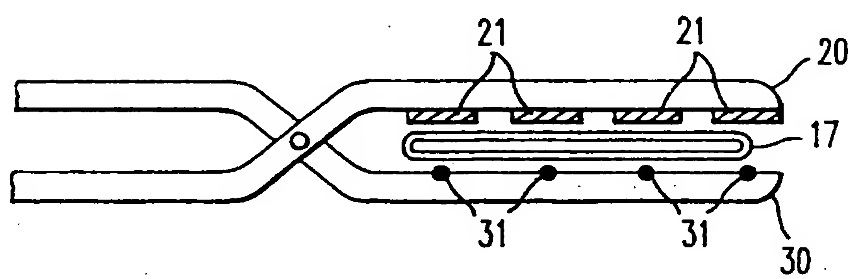
With amended claims.

(54) Title: COAGULATING FORCEPS

(57) Abstract



A method and apparatus for selectively coagulating blood vessels or tissue containing blood vessels (17) involves placement of the blood vessels or tissue containing blood vessels between prongs of a forceps (10) with the jaws (20, 30) of the forceps (10) containing a plurality of electrodes (21) which are energized by radio frequency power. A plurality of sensors (31) are associated with the electrodes (21) and in contact with the vessels or tissue in order to measure the temperature rise of the tissue or blood vessels and to provide a feedback to the radio frequency power in order to control the heating to perform coagulation of the vessels or tissue. In a further development, the upper prong of the device is split into two parts (38, 34) with a cutting blade (49) between the two upper parts (38, 39) in order to provide for cutting of the coagulated vessels subsequent to the coagulation. The cutting may be accomplished either mechanically or electro-surgically.

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TITLE OF THE INVENTION

COAGULATING FORCEPS

Cross-reference to Related Applications

This is a continuation-in-part of application serial no. 07/877,567, filed May 1, 1992, and serial no. 08/046,683, filed April 14, 1992.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method and an apparatus for an electrosurgical coagulation and cutting of regions of tissue or blood vessels over relatively large areas with temperature control.

Discussion of the Background

Surgical procedures and particularly electrosurgical procedures often require the complete cutoff of large regions of tissue, or the complete cutoff of the blood supply through a main artery before such surgery can be performed. A typical example is the requirement that the uterine artery be closed off before the uterus can be removed during a hysterectomy. The cutting off of the blood supply through the artery is accomplished by suture ligation, staples or clips or electrosurgical desiccation. Obviously, for large arteries, suture ligation is a difficult and long procedure which increases the time required for anesthesia resulting in an opportunity for complicating factors to arise. Aside from an increase in

the length of time, there is an obvious increase in the expense of the procedure. Furthermore, when such arteries or vessels require their blood supply to be cut off during an emergency surgery, the amount of time to control the bleeding from the large vessel is more than just an expense or a complicating factor: it is a life-threatening period of time required before the actual surgery may be accomplished. Obvicusly, there is a need for an improved method for ligation and the cutting off of larger vessels.

Although the above example addresses the cutting off of a main artery, in many instances the blood supply needs to be cutoff to large regions of tissue containing many blood vessels and also in many instances the cutting off of the blood supply to these tissues is all that is required. In other words, in many applications, what is required is only the stopping of blood supply to a region of tissue containing many blood vessels.

In a similar manner, when cutting through large regions of tissue containing blood vessels, considerable time is expended ligating the individual blood vessels into tissue. There is a need for an improved method of cutting coagulating of such type of large regions of tissue.

One of the approaches in the electrosurgical procedure to reliably seal off large areas is the utilization of a device which can accomplish the cutoff of the blood supply through the main artery or a plurality of smaller vessels.

Current electrosurgical devices face severe problems which either make their use inconvenient or severely limit their application or, in certain instances, entirely rule out the use of such electrosurgical devices. Prior art devices are inherently difficult to use over a large area or an extended linear region because it is difficult with current electrosurgical devices to produce coagulated tissue over such a large area or over such a long linear region. Furthermore, it is extremely difficult to know the degree of completion of coagulation because there is no feedback mechanism to determine when the coagulation is complete. Therefore, with the present electrosurgical devices it is entirely possible that the application of the device will have been stopped before completion of coagulation resulting in continued bleeding. It is equally possible that the device was applied for too long a time which, at best, is a waste of time and, at worst, could have caused other damage to adjacent tissue or could have burned the tissue intended to be coagulated, resulting in compromised sealing of tissue and the risk of continued bleeding.

Yet another difficulty with the present electrosurgical devices available for coagulation is the requirement for the use of multiple devices. That is, once coagulation has been completed, another device is necessary to cut the tissue.

Uniform coagulation over large areas of tissue using standard electrosurgical techniques is extremely difficult to achieve. This difficulty is due in part to the fact that it is not known how to determine the proper rate at which to apply energy or how to determine when the desired amount of coagulation has been achieved. If the energy is applied too rapidly, the superficial layers of tissue may desiccate too quickly and insulate the deeper tissues from further application of electrosurgical energy. If insufficient energy has been applied, the desired depth of penetration of the electrosurgical energy may never be achieved. The only feedback currently available to an operator of the prior art electrosurgical devices is the visible inspection of the surface of the tissue which is being coagulated or monitoring of the level of RF current. Surface inspection is no indication of any effect achieved in deeper layers of tissue. Similarly, a drop in RF current does not differentiate between the formation of an insulating superficial layer as complete desiccation. Thus, the application of electrosurgical procedures to cut off blood supply is a developed skill based upon experience which either requires separate training in this field or a stop-and-inspect procedure with even such procedure failing when the energy is applied too quickly because the deeper tissues may have become insulated from further heat application.

There thus exists a long-felt need for a rapid, efficient, safe and sure method and device for completely cutting off the blood supply through an artery for vessel and the subsequent cutting of the artery or vessel in order to prepare for a further surgical procedure.

A similar need exists for an efficient, safe and sure method and device for sealing or coagulating large areas of vascular tissue such as mesentery, bowel, mesoappendix, lung, fat tissue, lymph nodes, fallopian tubes, pedicles and the like.

SUMMARY OF THE INVENTION

Accordingly, one object of the present invention is to provide a novel apparatus and method for performing safe and rapid blood supply cutoff through an artery, a vessel, or other tissue in an efficient and sure manner without the need for visual inspection.

It is a further object of the present invention to provide a generic line of electrosurgical tools capable of supplying temperature-controlled electrosurgical energy over large areas.

It is also an object of the present invention to provide a single device which allows for both stoppage of blood supply and the cutting of the artery itself subsequent to stoppage of the blood supply.

These and other objects are accomplished by using a plurality of area electrodes and the individually controlling the energy delivered to each electrode by means of a switchable temperature feedback circuit.

It is a further object to provide a feedback means for monitoring temperature, impedance and power to provide a control algorithm for operation of the device.

The objects of the present invention are provided by way of a forceps including split jaws and having a plurality of electrodes as well as a plurality of temperature sensors wherein operation of the device is accomplished by a scissors-like movement of the forceps.

It is a further object of the present invention to provide a structure whereby the split jaws of the coagulating forceps have an intermediate cutting blade combined with said forceps in order to sever the ligated vessel in the center of a coagulated area.

It is a further object of the present invention to provide a coagulating forceps with electrosurgical generation energy applied through a switching circuit.

It is a further object of the present invention to provide bipolar delivery of energy to the coagulating forceps.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

Figures 1A and 1B show a general view of a coagulating forceps according to the present invention, with Figure 1B showing a close-up view of a compressed vessel being clamped by the forceps;

Figures 2A, 2B and 2C show a construction variation with Figure 2A illustrating the clamping of a vessel by a forceps having split upper and lower jaws, Figure 2B showing the addition of a cutting blade to a split upper jaw and Figure 2C illustrating a side position cutting blade for a single pair of upper and lower jaws;

Figure 3 illustrates a schematic structure for a power source controller system;

Figure 4 is an illustration of a schematic of a monopolar construction of the power delivery system;

Figure 5 is a schematic of a bipolar/monopolar construction of the power delivery system; and

Figure 6 is a coagulating linear patch.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, and more particularly to Figures 1A and 1B thereof, there is illustrated a coagulating forceps in accordance with the present invention.

Figure 1A and Figure 1B show that the forceps 10 having handles 11 and 12 forming a scissor-like arrangement by which the jaws 20 and 30 are brought into contact with the compressed vessel or tissue 17 as shown in Figure 1B. A plurality of electrodes 21 are shown on the upper jaw and a plurality of sensors 31 on the lower jaw. Although four electrodes 21 and four temperature sensors 31 are illustrated, any number and any arrangement or size of electrodes may be used depending upon the type of vessel or artery, vessel or other tissue which is to be cut off. That is, for different types of operations and for different types of arteries, vessels, or other tissues, different devices or forceps may be configured to conform with certain areas of the human body or certain access areas which are used in normal surgical procedures may be utilized. As an example, the forceps may be extended to form a needle-nose configuration or the size of the forceps may be reduced and accordingly the shape of the electrodes may be changed to take into account the size of the

forceps. Furthermore, the configuration of the scissors-like arrangement is for purposes of illustration and the jaws may take the form of a clamping structure having either a straight head or an angled head as is normally used in any of a variety of clamping devices used for surgical procedures. Additionally, the scissors-like structure may be replaced with any other mechanism that will cause the forceps jaws to be brought together when activated. In particular, various types of mechanisms typically used in devices for laparoscopic surgery would be available.

When the forceps of Figure 1 are used, a two-step procedure is involved in order to cut the vessel. That is, first the forceps 10 are clamped across the vessel as shown in Figure 1B and the tissue is heated for a predetermined period at a predetermined temperature in order to ensure the coagulation of the vessel. Then, the forceps is removed and a cutting device such as a knife or an electrosurgical cutting is used. This requirement of two devices in the two-step operation can be eliminated by the single device of Figure 2B.

The Figures 2A and 2B illustrate a bifurcated top jaw with the electrodes 21 on the top jaw being divided between each of the two parts 38 and 39 of the top jaw. The bottom jaw 41 is a flat surface having a groove 42. The bottom surface contains the sensors 46 identical to the sensors 31

in Figure 1B. Also shown in the Figure 2B is a cutting blade 49 schematically shown as attached to an electrosurgical unit power generator 50 of the type generally used for electrosurgical cutting procedure.

With the arrangement of Figure 2B, the multi-segmented electrodes are powered and the tissue is heated by the power source controller 150 until the compressed vessel is coagulated and then the cutting blade 49, which slides between the upper jaws 38 and 39, cuts through the tissue into the lower groove 42. With the embodiment of Figure 2B showing the connection of the cutting blade to the electrosurgical power unit 50, such cutting can occur by way of a normal electrosurgical action which involves a cutting by an arc between the blade and the bottom of the groove 42 of the lower jaw 41. Electrosurgical cutting requires less mechanical force and more completely assures the cutting of the tissue. Thus, a two-step operation is carried out using the same apparatus with the first step of the heating and coagulation of the tissue taking place separate from the actual cutting of the tissue. The cutting of the tissue is completely independent of the operation of the multi-segmented electrodes which have already accomplished the coagulation. When the cutting takes place, the power is no longer supplied to the multi-segmented electrodes. Subsequently, the cutting blade either directly by mechanical force or through the action

of an electrosurgical cutting accomplishes the actual cutting through of the tissue whose blood supply has been cut off by the prior coagulation. Essentially, this amounts to stopping blood flow on two sides of an area and then the subsequent cutting in the middle of the area with the stopping of blood flow and the cutting is accomplished by a single device. The Figure 2C illustrates a side blade cutting structure with a single pair of upper and lower jaws 38 and 41. The lower groove 42 still retains the cutting blade 49 after passing through the tissue in a manner similar to Figure 2B. The cutting action of the blade 49 can also be accomplished by an electro-surgical action in a manner similar to previously described operation of the cutting blade of Figure 2B. The exception to the operation of the instrument of Figure 2B is that the device of Figure 2C has a cutoff of blood supply or a coagulation on only one side of the area to be cut. Side cutting would be accomplished by the operation of the device of Figure 2C is useful in particularized areas of surgery which either do not require cutoff of blood supply on both sides of the tissue to be cut or require or prefer continued blood supply flow adjacent to one side of the cut area.

The Figure 3 is a schematic representation of the power source controller 150 of Figures 2A and 2B and the switch matrix for the multi-segmented forceps discussed in

conjunction with either Figure 1 or Figure 2. The electrical leads connect to the electrode-thermistor pairs of the forceps by way of connectors 138. The thermistor leads of the thermistors 31 (46) are connected to the matrix switchbank 134 and the electrode leads of electrodes 21 are connected to the switchbank 136. Each thermistor 31 (46) is sampled by means of a temperature measurement circuit 128 and the isolation amplifier 126 before being converted to digital form in the converter 116 and fed to the computer 114. The temperature measurement circuitry compares the measured temperature with a thermistor reference voltage 132. The electrode switch 136 is controlled in response to the output of the computer 114 by means of the opto-isolators 132. Input power from the RF input passes through the overvoltage and overcurrent protector 110 and is filtered by the bandpass filter 122 before being subjected to overvoltage suppression by the suppression unit 124. The voltage is isolated by means of transformers 138, 140 and 142 with the transformer voltages V_1 and V_2 from the transformers 142 and 144 being converted by the RMS-DC converters 118 into an RMS voltage to be fed to the converters 116. Prior to conversion, the signals V_1 and V_2 are also fed to the high-speed analog multiplier 120. RF control from computer 114 is provided through interface 112.

The Figure 4 provides a schematic representation of the connection of power source controller 150 of Figure 3 to a multi-segmented electrode forceps having an illustrated four electrodes. The illustrated embodiment of Figure 4 shows a monopolar construction having a connection to a patient ground pad 120. The electrodes 121-124 may correspond to the electrodes 21 in Figure 1b and may be located on the upper jaw 20 in line or they may be located as shown in Figure 2 with two of the electrodes being on one of the upper split jaws 38 and the other two being on the upper split jaw 39. Although four electrodes are shown in the Figure 4, there is no limit based upon the principles of operation. Neither is there a limit on the arrangement of a particular number of electrodes on a particular portion of the jaw. The nature of the surgery to be performed and particularly the nature of the device for performing such surgery will provide the impetus for the size of the electrodes and the number of electrodes and the positioning of the electrodes on the forceps.

In the illustration of Figure 4, there is a voltage from the controlled power source being fed to one or more of the electrodes 121-124 depending on the condition of the switches 111-114. This is a monopolar operation and the grounding occurs by way of the patient ground pad 120. The temperature sensors 31 are not shown in the Figure 4 embodiment for purposes of simplification but would be

clearly positioned in a manner similar to Figure 1 and Figure 2 and the outputs would be fed to the device of Figure 3.

Any large tissue area or vessel which needs to be coagulated can be covered by a number of electrodes by segmenting the large area into a number of smaller area electrodes of the type 121-124. With this type of structure of smaller area electrodes, individual control of the energy to each electrode through the switching circuit of Figure 4 is available in order to achieve controlled coagulation over a large area of tissue. The temperature sensors 31 or 46 are employed to sense the tissue temperature. Allowing the tissue temperature to reach a desired value and maintaining that temperature at that level for an appropriate period of time provides the physician with feedback concerning the coagulation process which would be impossible to achieve with a visible inspection of the surface tissue of the vessel being coagulated. This temperature feedback ideally provides for the control of the depth of the treatment and uses what is known as a "slow cook" of the tissue over a period of anywhere from several seconds to several minutes to achieve the desired therapeutic affect of cutting off the blood flow.

Studies of thermotolerance of cells indicate that maintaining cells at 43°C for one hour produce a cell

death. The time required is halved for each degree centigrade increase above 43°C. Cell death occurs because cellular enzymes necessary to support metabolism are destroyed.

The multi-electrodes/temperature feedback concept for coagulating large areas or linear regions can be improved with respect to the delivery of energy to particular points by way of the switching arrangement of Figure 5 which provides for the ability to use either a monopolar operation or a bipolar operation. Figure 5 utilizes the same four electrodes 121-124 and a similar voltage source 210 with the same patient ground pad 120 as used in Figure 4. The essence of the Figure 5 monopolar/bipolar switching arrangement is that the physician or operator has the ability to provide either monopolar or bipolar operation. When switch 220 is closed and the switches 216-219 remain open, the device functions essentially the same as the Figure 4 embodiment. That is, it provides monopolar operation. On the other hand, if the switch 220 is opened and if pairs of switches, with one of the pair being selected from the switch 211 to 214 and the other being selected from 216 to 219, are operated in proper conjunction, the electrodes 121-124 will provide a bipolar operation. As an example, if switch 214 is closed as well as switch 218, then the current will pass from electrode 121 to electrode 123. In a similar manner, if switch 213

is closed as well as switch 219, there will be a bipolar operation with current flowing between electrode 122 and 124. Bipolar operation is not limited to these 121-123 and 122-124 pair couplings because if switch 214 and switch 217 are closed there will be bipolar operation between the electrodes 121 and 122 with current passing from 121 to 122.

The embodiment of Figure 5 not only provides a choice between monopolar and bipolar operation but also provides a flexibility within the bipolar operation so that any two or any combination of pairs of electrodes 121-124 may be utilized together. Obviously, if switch 214 were thrown in conjunction with switch 216, nothing would occur because there would be a short. The operation in a bipolar mode provides the additional flexibility whereby some of the electrodes may be positioned on the top half and the bottom half respectively of the jaws of the forceps 10. That is, instead of the forceps having the electrodes positioned in line on the top jaw 20 as shown in Figure 1, they may be positioned with two electrodes 121-122 on a top jaw and electrodes 123 and 124 on the bottom jaw. Of course, the same remains true with respect to any number of electrodes other than the four shown in the embodiment of Figures 4 and 5.

The Figure 6 illustrates an embodiment utilizing the electrode arrangement concept and the temperature sensor

feedback concept to provide effectively a patch which may be used to control or stop surface bleeding. The patch contains multiple electrodes 330 and an associated temperature sensor 340 with the size of the patch 350 being dependent upon physiologic considerations and desired area of coverage. The same is true with respect to the choice of the number of sensors and the number of associated electrodes. The feedback mechanism control by way of the Figure 3 power source would function in the same manner except that a physician would control the operation of the feedback mechanism to provide temperatures which would correspond to the requirements of the injury on the surface of the person receiving this patch. Although the operation would be dependent upon the type of injury or the type of surface to be controlled with respect to blood flow, it provides a slow cooking process at a stabilized and controlled temperature so that all areas underneath the patch 350 may be treated in a uniform manner without "hot spots" which would cause either injury or undesirable and uneven control of bleeding while also unnecessarily cauterizing tissue.

The use of a coagulating forceps provides uniform coagulation over large areas of tissue by providing the proper application of energy to provide the desired depth of penetration without reliance on a visible inspection of the surface of the tissue or vessel being coagulated. The

ability to segment the large area electrosurgical electrode into a number of smaller area electrodes and individually controlling the energy to each electrode through the multiplexing circuit of either Figure 4 or 5 provides a degree of flexibility beyond the state of the art as well as a degree of assurance heretofore unknown. Thus use of many small electrodes is generally preferable to single large electrode. The advantage of many small electrodes is better controlled such as the ability to cause tissue to reach a therapeutic temperature with a small amount of power.

The temperature sensors provide the feedback mechanism which allows the tissue temperature to reach a desired value and be maintained at that level for an appropriate period of time. This provides necessary information concerning the coagulation process which would otherwise be unavailable to the physician. The monitoring of the tissue impedance and the actual delivered power provide the ability to control the coagulation precisely. Once this coagulation is controlled to the satisfaction of the physician and the coagulating job has been completed, the cutting mechanism, either by way of electrosurgical cutting or manual cutting, severs the ligated vessel in the center of the coagulated area as shown in the embodiment of Figure 2. Any number of sets of electrodes can be utilized depending upon the area and the location of the area to be

coagulated and the head of the forceps can be angled or otherwise maneuvered using many of the same physiologic considerations provided for the selection of any surgical tool subject to electrical connection to the power generation source and the number of wires and space required for such connection.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

WHAT IS CLAIMED AS NEW AND DESIRED TO BE SECURED BY LETTERS PATENT OF THE UNITED STATES IS:

1. An implement for selectively coagulating blood vessels or tissues containing blood vessels, comprising:

at least two opposable members and a means for permitting movement of said at least two opposable members toward and away from each other;

electroconductive electrode means positioned on at least one of said at least two opposable members for effecting electrical contact with said vessels to be coagulated;

radio frequency power means connected to said electrode means for selectively providing current to said electrode means to thereby provide for coagulation of said vessels positioned between said at least two opposable members.

2. The implement according to claim 1, wherein said electroconductive electrode means includes a plurality of separate electrodes positioned on one of two opposable members.

3. The implement according to claim 2, further including a switching means for providing individual control of power to each of said separate electrode means.

4. The implement according to claim 2, wherein one of said at least two opposable members has a first portion containing at least one electrode member and a second

portion spaced from said first portion and containing at least another electrode member, said implement further including a cutting means positioned between said first and second portion of said one opposable member for providing cutting of said coagulated vessels positioned between said opposable members.

5. The implement according to claim 4, wherein one of said opposing members includes a groove for receiving said cutting member after cutting said vessel member.

6. The implement according to claim 4, wherein said cutting member further includes a cauterizing power source to provide electrosurgical cutting.

7. The implement according to claim 1 further including temperature sensing means positioned on at least one of said at least two opposable members.

8. The implement according to claim 3, wherein said switching means includes a means for selecting at least one of monopolar and bipolar power to said electrode means.

9. The implement according to claim 8, wherein said switching means includes a means for providing bipolar energy to said electrodes.

10. The implement according to claim 9, wherein said electrodes a first plurality of separate electrodes positioned on one of said two opposable members and a second plurality of separate electrode positioned on the other one of said two opposable members.

11. An implement for selective application of RF energy to heat and thereby to coagulate blood vessels or tissue containing blood vessels, comprising:

electroconductive electrode means for effecting electrical contact with a blood vessels to be treated, said electrode means including a plurality of separate electrodes and an associated plurality of respective temperature sensing means; and

power generation means for delivering radio-frequency energy to said electrode means for selectively providing controlled current to said blood vessels to coagulate said blood vessels.

12. A method for selectively coagulating blood vessels or tissue containing blood vessels, comprising the steps of:

securing said vessels between two opposable members in contact with said vessels;

applying radio-frequency energy to at least one of said two opposable members;

measuring the temperature of said blood vessels;

selectively controlling the application of said radio-frequency energy as a function of said sensed temperature in order to provide coagulation of said vessels.

13. The method according to claim 12 further comprising the step of cutting said vessels subsequent to said coagulation.

14. The method according to claim 13, wherein the step of providing radio-frequency energy includes the step of providing a plurality of electrodes on at least one of said two opposable members.

15. The method according to claim 12, wherein the step of providing radio-frequency energy includes the step of providing monopolar radio-frequency energy.

16. The method according to claim 12, wherein the step of providing radio-frequency energy includes the step of providing at least one of bipolar energy and monopolar energy.

17. The method according to claim 15, wherein the step of applying radio-frequency energy includes the step of providing a plurality of electrodes on each of said two opposable members and wherein the step of providing at least one of bipolar and monopolar energy involves the step of providing bipolar energy to at least two of said electrodes.

AMENDED CLAIMS
[received by the International Bureau on 18 February 1995 (18.02.95);
original claims 2 and 12-17 cancelled;
original claims 1 and 3-11 amended;
remaining claims unchanged (2 pages)]

1. An implement for selectively coagulating blood vessels or tissues containing blood vessels, comprising:

at least two opposable members and a means for permitting movement of said at least two opposable members toward and away from each other;

a plurality of electrically isolated separate electrodes positioned on at least one of said at least two opposable members for effecting electrical contact with said vessels to be coagulated; and

radio frequency power means connected to said electrodes for selectively providing current to said electrodes to thereby provide for coagulation of said vessels positioned between said at least two opposable members.

3. The implement according to claim 1, further including switching means for providing individual control of power to each of said separate electrodes.

4. The implement according to claim 1, wherein one of said at least two opposable members has a first portion containing at least one electrode and a second portion spaced from said first portion and containing at least another electrode, said implement further including a cutting means positioned betwen said first and second portions of said one opposable member for providing cutting of said coagulated vessels positioned between said opposable members.

5. The implement according to claim 4, wherein another of said opposable members includes a groove for receiving said cutting means after cutting said vessels.

6. The implement according to claim 4, wherein said cutting means further includes a cauterizing power source to provide electrosurgical cutting.

7. The implement according to claim 1 further including temperature sensing means positioned on at least one of said at least two opposable members.

8. The implement according to claim 3, wherein said switching means includes means for selecting at least one of monopolar and bipolar power

to said electrodes.

9. The implement according to claim 8, wherein said switching means includes means for providing bipolar energy to said electrodes.

10. The implement according to claim 9, wherein a first plurality of separate electrodes is positioned on one of said at least two opposable members and a second plurality of separate electrodes is positioned on another one of said at least two opposable members.

11. An implement for selective application of radio frequency energy to heat and thereby to coagulate blood vessels or tissue containing blood vessels, comprising:

electroconductive electrode means for effecting electrical contact with blood vessels to be treated, said electrode means including a plurality of separate electrodes and an associated plurality of respective temperature sensing means; and

power generation means for selectively delivering radio frequency energy to said electrodes for selectively providing controlled current to said blood vessels to coagulate said blood vessels.

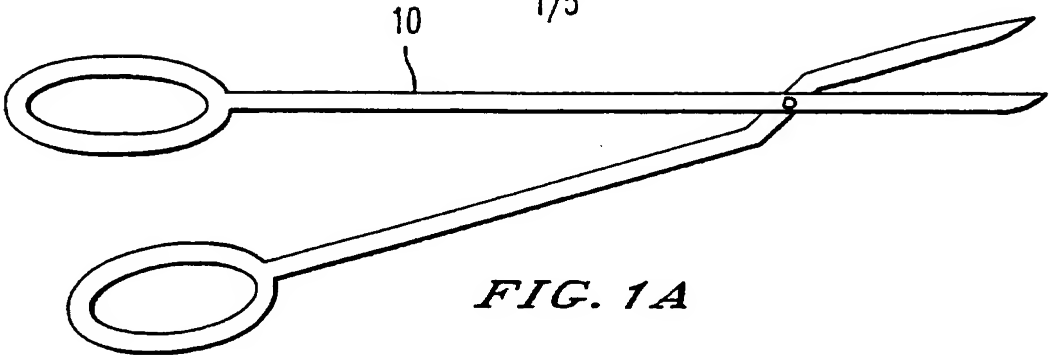


FIG. 1A

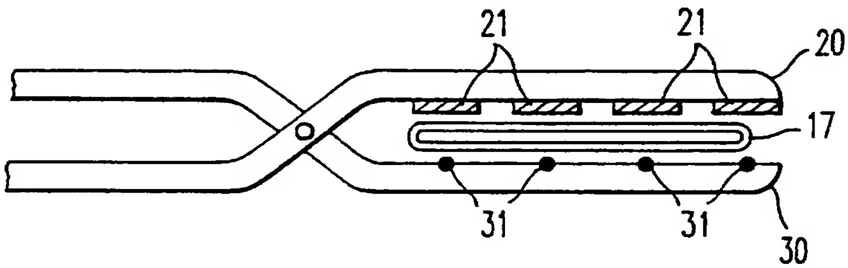


FIG. 1B

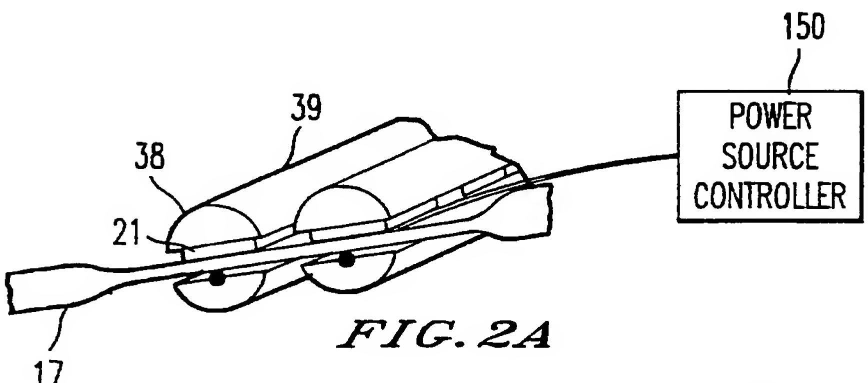


FIG. 2A

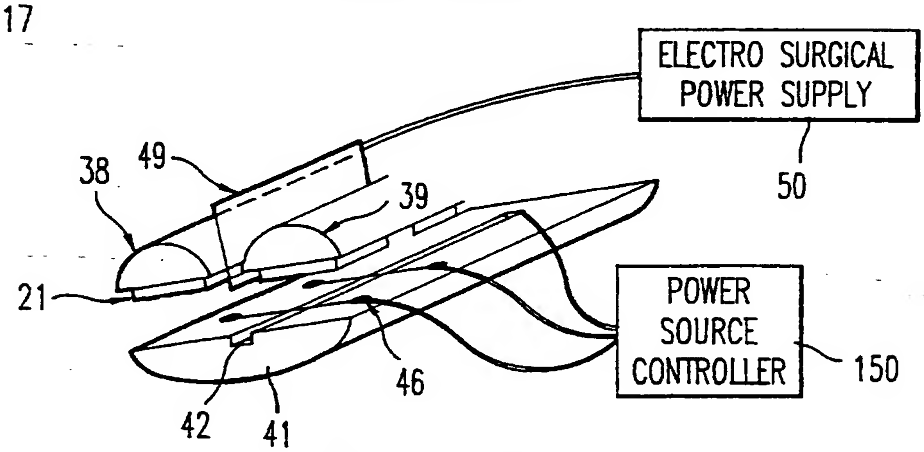


FIG. 2B

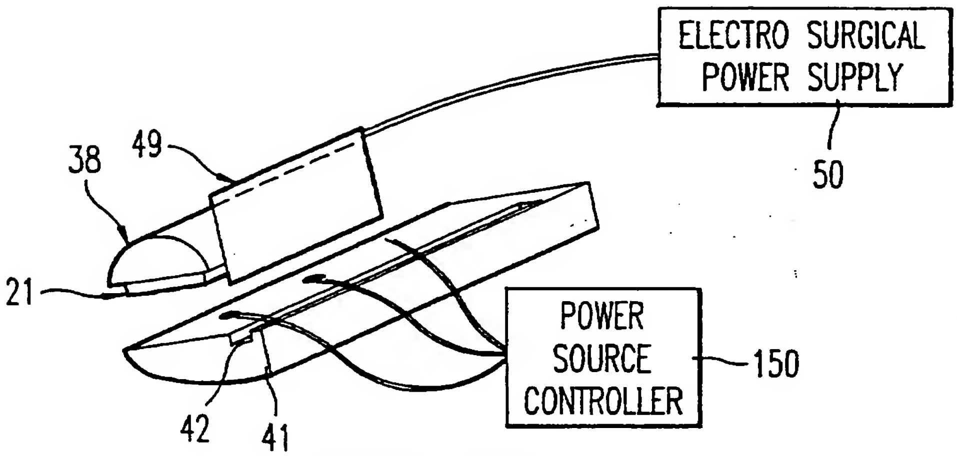

ELECTRO SURGICAL POWER SUPPLY
50
49
38
21
POWER SOURCE CONTROLLER
150
42
41

FIG. 2C

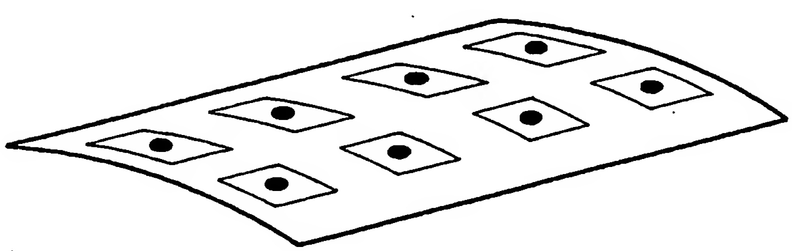
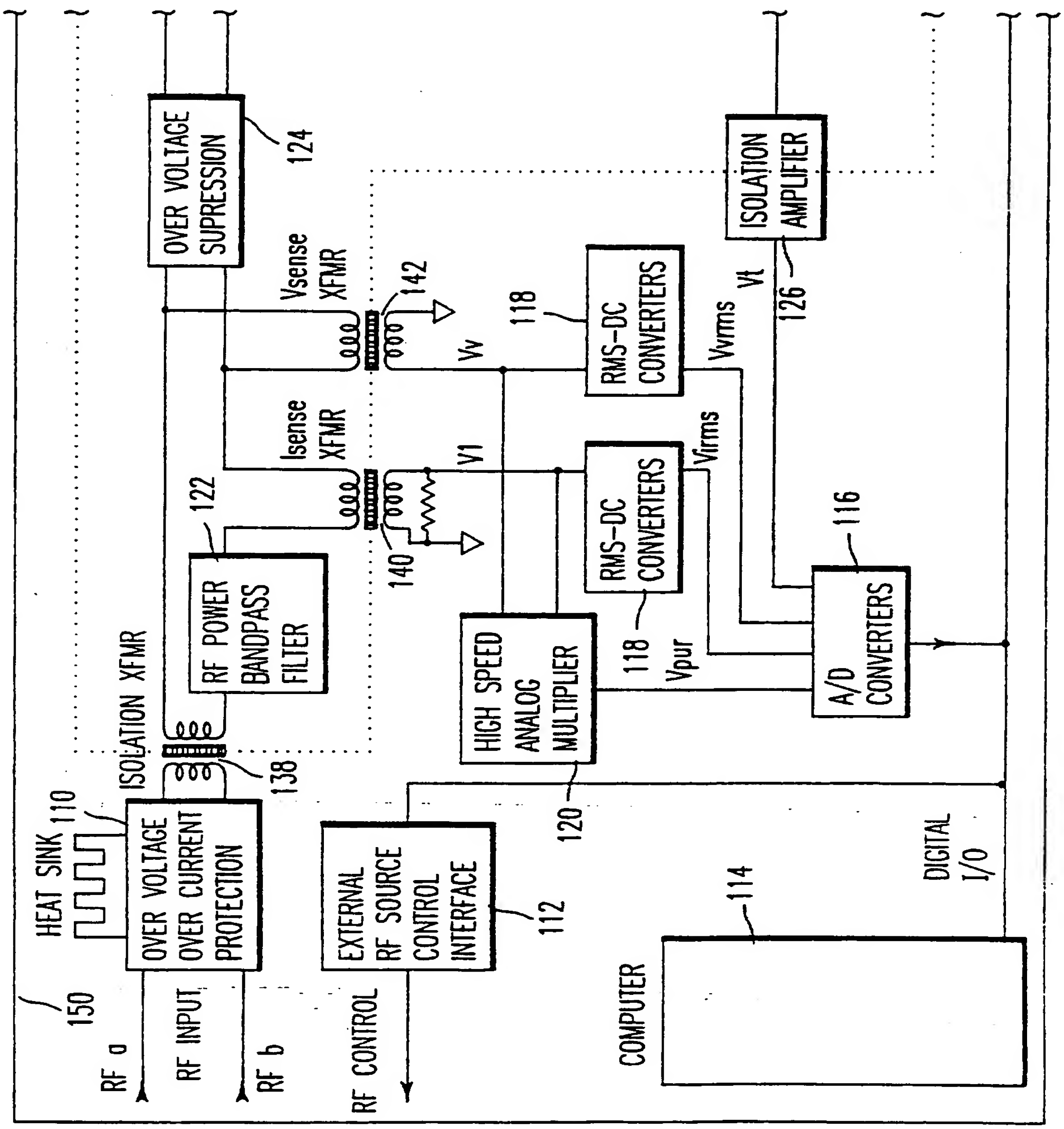


FIG. 6

FIG. 3A


OVER VOLTAGE SUPRESSION
124
Vsense XFMR
142
Vv
118
RMS-DC CONVERTERS
Vvrms
Vt
ISOLATION AMPLIFIER
126
Isense XFMR
V1
122
RF POWER BANDPASS FILTER
140
RMS-DC CONVERTERS
Virms
116
A/D CONVERTERS
HIGH SPEED ANALOG MULTIPLIER
118
Vpur
ISOLATION XFMR
138
HEAT SINK
110
OVER VOLTAGE OVER CURRENT PROTECTION
120
EXTERNAL RF SOURCE CONTROL INTERFACE
112
114
DIGITAL I/O
150
RF a
RF INPUT
RF b
RF CONTROL
COMPUTER

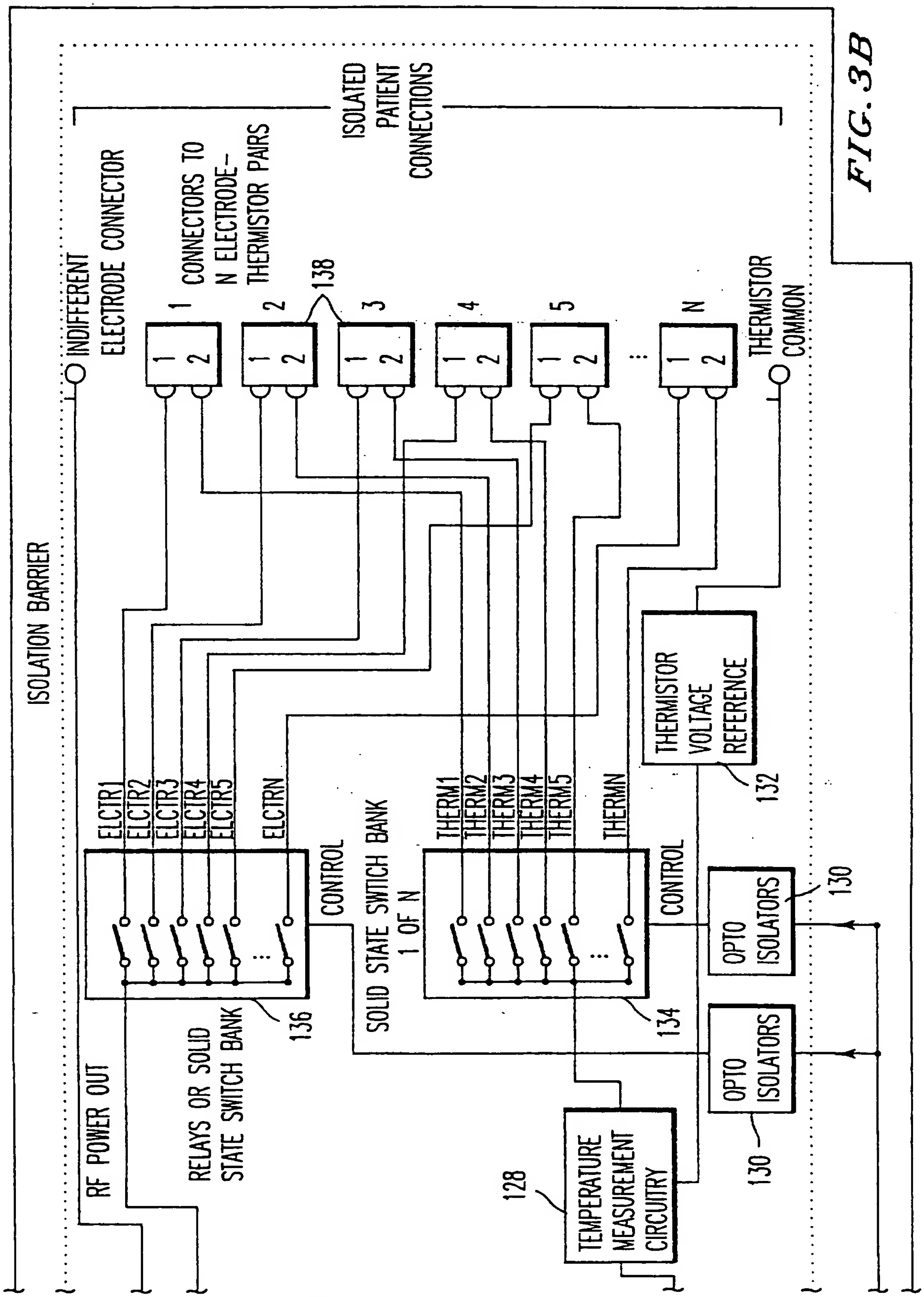

ISOLATED PATIENT CONNECTIONS
INDIFFERENT ELECTRODE CONNECTOR
CONNECTORS TO N ELECTRODE-THERMISTOR PAIRS
138
1
2
3
4
5
N
THERMISTOR COMMON
ISOLATION BARRIER
ELCTR1
ELCTR2
ELCTR3
ELCTR4
ELCTR5
ELCTRN
THERM1
THERM2
THERM3
THERM4
THERM5
THERMN
THERMISTOR VOLTAGE REFERENCE
132
CONTROL
SOLID STATE SWITCH BANK 1 OF N
CONTROL
OPTO ISOLATORS
130
136
134
OPTO ISOLATORS
130
RF POWER OUT
RELAYS OR SOLID STATE SWITCH BANK
128
TEMPERATURE MEASUREMENT CIRCUITRY

FIG. 3B

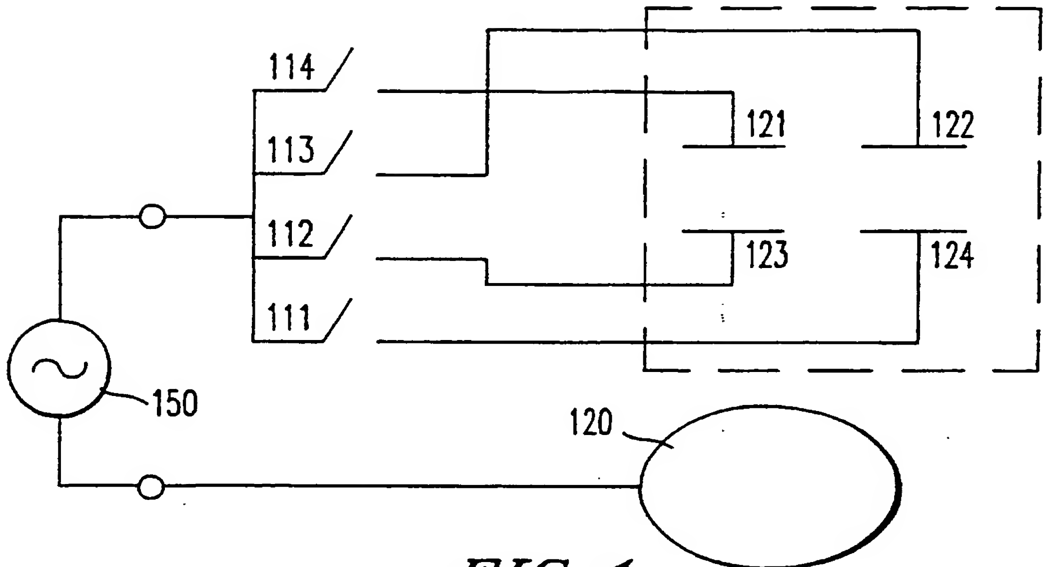

114
113
112
111
121
122
123
124
150
120

FIG. 4

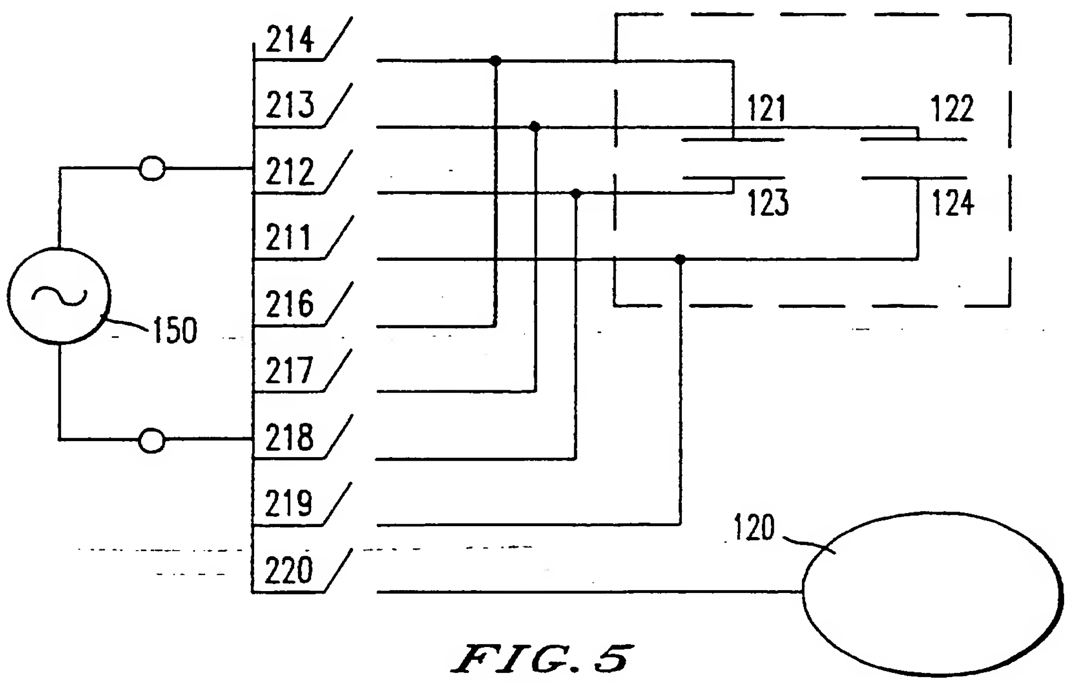

214
213
212
211
216
217
218
219
220
121
122
123
124
150
120

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/09408

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :A61B 17/39
US CL :606/45, 49
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 606/41, 42, 45, 46, 48-52

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US, A, 5,122,137, (LENNOX), 16 June 1992. See column 4 lines 54 - column 5, line 16.	1, 7, 11, 12, 15, 16 --- 7, 12-16
X --- Y	US, A, 5,190,541, (ABELE ET AL.), 02 March 1993. See column 5 line 59 - column 6 line 29.	1, 2, 4, 6 --- 7, 12-16
Y	US, A, 4,655,216, (TISCHER), 07 April 1987. See column 4 line 12 - column 5 line 43.	12, 13, 15, 16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search

18 OCTOBER 1994

Date of mailing of the international search report

06.12.94

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